

7. VOLATILE ORGANIC COMPOUND ANALYSIS

This chapter examines the impact of volatile organic compound (VOC) emissions from substitutes to ozone-depleting substances (ODSs) currently in use in aerosol products by comparing possible emissions to background VOC releases.

VOC emissions are direct contributors to surface-level (i.e., tropospheric) ozone formation, which in turn causes adverse health and environmental effects. The analytical approach used is similar to that used for the other industry sectors being evaluated by EPA under section 612 of the Clean Air Act as amended in 1990 (CAA). Briefly, EPA used worst-case screening assumptions to estimate VOC emissions from the substitutes both nationwide and in six "test" areas of the country (based on the six recognized types of attainment/nonattainment of surface-level ozone). For the regional analysis, EPA estimated the emissions from aerosol products released in three sectors: manufacturing, household, and industrial based on available information. EPA then compared the VOC emission estimates to total VOCs from all sources to obtain percent increases nationwide and in the six test areas. EPA also calculated for the most impacted area the screening-level (i.e., conservative worst-case) increases in surface-level ozone that could occur, and compared this to the amount that would be needed to move an area from one level of attainment/nonattainment to the next worse level.

Section 7.1 presents EPA's approach to estimating potential increases in VOCs released from aerosol products and the background VOCs (i.e., from all sources). Section 7.2 presents a comparison of the two. Attachment 7-A provides details on the calculation of total (background) VOCs. Attachment 7-B describes the expected impact of VOC controls. Attachment 7-C reviews calculations that were used to determine worst case releases from a manufacturing facility.

7.1 APPROACH TO ESTIMATING POTENTIAL INCREASE IN VOC EMISSIONS

This section addresses the approach that EPA used to estimate VOC emissions from substitutes of currently used ODSs. The comparison "test" areas of the U.S., the use sectors, and methodologies for calculating emissions are described below.

7.1.1 Comparison Areas

EPA compared the VOC emissions from aerosol products to total VOC emissions from all sources on a national and a regional level. The national-level analysis examined estimated emissions from all products expected to be substituted with VOCs. At the regional level, EPA examined six areas: five areas corresponding to the five types of surface-level ozone nonattainment areas¹ -- extreme, severe, serious, moderate, and marginal -- and one area corresponding to an attainment area. The selected areas include:

- Los Angeles--South Coast (extreme nonattainment);
- Philadelphia-Wilmington-Trenton (severe nonattainment);
- Atlanta (serious nonattainment);
- Dallas-Fort Worth (moderate nonattainment);
- Indianapolis (marginal nonattainment); and
- Hennepin, Minnesota (attainment).

¹ As defined by CAA section 181.

These areas include the cities and the surrounding greater metropolitan areas. These attainment/nonattainment areas were chosen randomly within each attainment/nonattainment category from a sample of areas on which EPA had data from the Urban Airshed Model (UAM) (see Attachment 7-A). These areas were not meant to be representative of or to capture large numbers of aerosol manufacturing or industrial facilities or high consumer uses of aerosol products.

7.1.2 VOCs from All Sources

The VOCs from both anthropogenic and biogenic sources are considered for purposes of this analysis as emissions of VOCs from all sources (i.e., background). Refer to Attachment 7-A for the breakdown of total emissions for the nation and for each of the six areas as taken from the UAM. These amounts are compared to the potential VOC emissions from aerosol products, as described in a later section.

7.1.3 Estimating Ambient Air Releases of VOCs Nationally and Regionally in the Aerosol Sector

For the purpose of this analysis, EPA assumed that all ODSs currently used in aerosol products will be completely replaced by VOCs and that all the VOCs sold for use in aerosol products will be released to the atmosphere.

7.1.3.1 National Releases

The VOC release estimates are based on the total consumption of ODSs used in the aerosol sector assuming a one-to-one conversion. Total emissions of ODSs used in the aerosol sector equals the sum of the releases of HCFC-22, CFC-11, CFC-113, and MCF.²

Currently used ODSs released annually in the aerosol sector were estimated as follows:

HCFC-22	5.1 million kg
CFC-11	1.3 million kg
CFC-113	3.3 million kg
MCF	33.2 million kg

<p>The National Release of ODSs Annually in Aerosol Products was estimated as 42.9 million kg.</p>
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7.1.3.2 Regional Releases

VOC emissions from aerosol products result from three distinct sectors: manufacturing facilities, household use, and industrial sites. EPA determined release estimates for each sector based on the following approach:

² CFC-12 and CFC-114 were not included in the total national releases because they are used in medical applications and substitutes for these products are in the developmental stage.

Manufacturing Releases

A significant quantity of emissions are released during the manufacture of aerosol products. These quantities differ for propellants and solvents. Propellants are, by nature, more volatile compounds, thereby contributing a larger share to releases during the filling process than the less volatile solvent compounds. Although, estimates were available for the total release of currently used ODSs in the manufacture of aerosol products, it was not possible to correlate this information on a regional basis.

However, EPA was able to locate filling stations for the six specific regional areas from a previous study (EPA 1987) that identified aerosol filling stations around the U.S. For those regions that did not have an aerosol filling facility, EPA assumed that one such facility existed.

Worst-case assumptions were used to estimate the releases from two different model aerosol filling facilities, manufacturing either propellant or solvent aerosol products. To estimate these releases, EPA took into account the rate of production of aerosol units, shifts per day, size of unit, percent ODS per unit, and the percent loss of total propellant (see Attachment 6-A for detailed calculations).

Based on the worst-case release estimates for propellant and solvent aerosol manufacturing facilities, EPA estimated annual releases for a model facility that manufactured both propellant and solvent products (see Attachment 7-C for explanation).

<p>Annual Releases for Model Facility Using ODSs as Propellants and Solvents are: 21,200 kg</p>

Household Releases

To determine the VOC emissions released from the household use of aerosol products, the following approach was taken:

- Aerosol products using ODSs were separated into household and industrial uses based on product description information (EPA 1992).
- National consumption of ODSs in household products were determined by adding the quantities of ODSs used in each product (EPA 1991). The national consumption of ODSs in household products for 1988 was 22.5 million kg. (See section 6.2.1 for explanation.)
- Regional household consumption of ODSs used in the aerosols sector was calculated by taking a proportion of the national consumption as a ratio of the population of the regional area to that of the total U.S. population (Census 1986). These consumption estimates are based on the assumption that household use of aerosol products is population dependant.

<p>Regional Breakdown of Consumption of ODSs in Household Products:</p>

<p>Hennepin, Minnesota: 86,500 kg Indianapolis: 69,000 kg Dallas-Fort Worth: 293,300 kg Atlanta: 209,400 kg Philadelphia: 519,800 kg Los Angeles: 1,144,700 kg</p>
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Industrial Releases

Since it was difficult to obtain regional industrial emissions, EPA estimated releases from a worst-case industrial facility, assumed each region had one facility, and assumed that the greatest industrial release of ODSs would take place in companies using mold release agent. The annual emissions estimates for the worst-case facility were based on the information obtained from the Toxic Release Inventory (TRI) by cross-referencing the SIC #3089 for plastic products with those companies using ODSs.

Annual Releases from Worst-Case Industrial Site: 58,600 kg
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The annual releases from this facility were added to the manufacturing and consumer releases to estimate the annual emissions of VOCs replacing ODSs used in aerosol products for the six specific regions in the U.S. EPA then compared these releases to total annual background releases within the various regions to obtain the percent increase in each region's VOC loading. The annual VOC emissions estimates are shown in Exhibit 7-1.

EXHIBIT 7-1
INCREASES IN TOTAL ANNUAL VOC FROM AEROSOL PRODUCTS

Non/Attainment Area	VOC Releases from All Sources (millions of kg)	VOC Releases from Aerosol Products (millions of kg)	Percent Increase in VOCs From Aerosol Products
Attainment--Hennepin, Minnesota	76.5	0.16	0.21
Marginal--Indianapolis, Indiana	66.6	0.15	0.23
Moderate--Dallas-Fort Worth, Texas	558	0.37	0.07
Serious--Atlanta, Georgia	646	0.32	0.05
Severe--Philadelphia-Trenton-Wilmington*	900	0.63	0.07
Extreme--Los Angeles	962	1.22	0.13
National	21,100	42.9	0.20

* There are two "Severe" classifications, "Severe-15" and "Severe-17." EPA has combined them into one category.

7.2 COMPARISON OF VOCs FROM SUBSTITUTES TO VOCs FROM ALL SOURCES

EPA examined emissions of VOCs from aerosol products as a percentage of total VOC emissions from all sources. The results are summarized in Exhibit 7-1. Note that, as discussed below, this is a screening-level analysis; the VOC increases described here are not actually expected to occur.

As shown in Exhibit 7-1, for all six areas, the screening-level worst-case increase of VOC emissions are all less than a quarter of one percent. Indianapolis, being the smallest emitter of total VOCs, shows the greatest increase in VOCs (0.23 percent) from aerosol products. The worst-case manufacturing and industrial facilities placed in that region had a significant impact on emissions. Furthermore, and more importantly, a 0.23 percent increase in VOC emissions would result in a much smaller than 0.23 percent increase in ozone concentration. For example, using data from Systems Applications International (SAI)³ (1992), and assuming that a whole month's VOC emissions occur instantaneously and enter a 3,000 foot high column of air over Indianapolis, ozone levels would increase about 13.3 ppt. When added to Indianapolis' current ozone level of 0.121 ppm, EPA finds that the increase would be less than the amount needed to change Indianapolis' ozone classification to the next worse level (i.e., moderate at 0.138 ppm ozone). Finally, as discussed in Attachment 7-B, new sources of emissions in ozone non-attainment areas are subject to the New Source Review (NSR) program, which will require major sources to achieve the lowest achievable emissions, among other requirements. These provisions will help mitigate the emissions of VOCs estimated from releases from aerosol products in manufacturing facilities and industrial sites.

7.3 CAVEATS AND LIMITATIONS

EPA believes that VOC emissions and impacts from the releases from aerosol products are overstated for several reasons.

- The replacement ratio for many VOC substitutes, such as propane, might be less than one, which would cut emissions.
- Exempt VOCs, such as methylene chloride, may continue to be used in some aerosol products.
- VOC emissions controls have not been considered.
- At the regional level, when EPA did not have precise emissions data, EPA defaulted with emissions from at least one large facility. The evidence EPA does have suggests that facilities this large are not located in the test areas.
- The VOC increases described in this analysis would result in relatively low ozone increases, especially considering the controls discussed in Attachment 7-B.
- To test the increase in ozone concentrations in the lower atmosphere above Indianapolis, a whole month's emission were instantaneously released into the air. The increase in ozone concentration would be much more gradual over the month and not reach so high a concentration.

³ This mass-balance model was developed by ICF Incorporated as a simple screening-level tool for calculating a "bounding" estimate of VOC increases from ODS substitutes. This model was not peer-reviewed by EPA, nor was it developed for purposes of determining a central tendency or even a high end estimate of potential increases in VOC concentrations.

CHAPTER 7 REFERENCES

- ICF Incorporated. 1992. *Releases of Substitutes in the Aerosol/Pressurized Dispenser Sector*. Memo from Farzan Riza and Keith Bowers of ICF Incorporated to Nina Bonnelycke and Elaine Haemisegger of the U.S. EPA, Office of Air and Radiation, Global Change Division.
- Systems Applications International (SAI). 1992. May-June. San Rafael, CA. Personal communication with Steven Reid.
- U.S. Department of Commerce. 1986. *State and Metropolitan Area Data Book*, Bureau of the Census.
- U.S. EPA. 1992. *Revised Draft Report on The Use and Substitutes for Class I Substances in Aerosol Products/Pressurized Dispensers*. Office of Air and Radiation, Global Change Division. May 22, 1992.
- U.S. EPA. 1992. *Draft Background Document on Identification of Nonessential Products that Release Class I Substances*. Office of Air and Radiation, Global Change Division. November, 1992.
- U.S. EPA. 1989. *Alternative Formulations to Reduce CFC Use In U.S. Exempted and Excluded Aerosol Products*. Office of Research and Development, Washington D.C. November, 1989.
- U.S. EPA. 1987. *National List of Aerosol Packagers*. Chemicals and Petroleum Branch, Research Triangle, NC.

ATTACHMENT 7-A
ESTIMATION OF TOTAL VOC EMISSIONS FROM ALL SOURCES IN 1995

The estimates for total VOC emissions from all sources incorporate both anthropogenic (including mobile sources) and biogenic sources. For Los Angeles, Philadelphia, Atlanta, and Dallas, EPA extracted estimates of VOC emissions for 1995 directly from the latest *Urban Airshed Model* results (June 1990).⁴ For Indianapolis and Hennepin, EPA did not have VOC emissions estimates for 1995 (nor did EPA have data for any other marginal non-attainment or attainment area). EPA also did not have readily available anthropogenic and biogenic estimates for nationwide 1995 VOC emissions. Therefore, EPA first obtained anthropogenic emissions for 1985 from the National Acid Precipitation Assessment Program (NAPAP) emissions inventory. These 1985 figures then were adjusted for 1995 using economic indicator data from the Bureau of Economic Analysis (BEA) *Regional Projections Data System* (June 1990). The biogenic emissions were obtained by averaging seasonal biogenic data from the *Regional Biogenic Emissions Inventory System* (1990)⁵. These biogenic emissions were assumed to remain the same for 1995. The figures obtained from this analysis are presented in Exhibit 7-A-1.

EXHIBIT 7-A-1
TOTAL VOC EMISSIONS FROM ALL SOURCES IN 1995 (TONS)

Area	Current Status	Anthropogenic Emissions	Biogenic Emissions	Total VOC Emissions
Los Angeles, CA	Extreme Non-attainment	762,485	295,285	1,057,770
Philadelphia, PA	Severe Non-attainment	760,295	230,315	990,610
Atlanta, GA	Serious Non-attainment	244,550	466,105	710,655
Dallas, TX	Moderate Non-attainment	360,620	253,310	613,930
Indianapolis, IN	Marginal Non-attainment	71,588	1,718	73,306
Hennepin, MN	Attainment	82,022	2,078	84,100
United States	--	--	--	23,176,700

⁴ UAM, managed by Systems Applications International, is a three dimensional photochemical grid model designed to calculate concentrations of both inert and chemically reactive pollutants by simulating physical and chemical processes that occur in the atmosphere. UAM is EPA's recommended model for photochemical pollutant modeling applications involving entire urban areas. For more information, see: EPA, *User's Guide for the Urban Airshed Model*, developed by Systems Applications International for Office of Air Quality Planning and Standards, June 1990.

⁵ Systems Applications International. 1990. *VOC Analysis Support*. Memorandum from Steve Reid, SAI, to Shailendra Reddy, ICF. March 19, 1990.

ATTACHMENT 7-B VOC CONTROLS

Facilities in ozone nonattainment areas switching from ODSs to VOCs may be required to offset the VOC emissions from their facility so that net VOC emissions decrease within the nonattainment area.

Within nonattainment areas major sources of emissions are subject to the provisions of the New Source Review (NSR) program. This program requires affected sources to reduce emissions to the lowest achievable emissions rate (LAER), and to offset new VOC emissions increases with reductions obtained within the facility or at other facilities located within the nonattainment area.

The NSR program affects "major sources" in nonattainment areas, and the definition of major source depends primarily upon the potential of the source to emit pollutants (potential emissions). Potential emissions are the amount of pollutant the source is capable of emitting in the absence of any Federally enforceable emission limitation. These amounts are similar to those estimated for individual facilities in the SNAP analyses. The potential emissions necessary for a source to be defined as major is a function of the classification of the ozone nonattainment area, with the amount of emissions necessary to be defined as a major source becoming smaller as ozone nonattainment problems of the area become greater (Exhibit 7-B-1).

EXHIBIT 7-B-1 MAJOR SOURCE DEFINITION AND OFFSET REQUIREMENTS

Nonattainment Area Classification	Major Source Definition (Tons per Year)	Offset Ratios (VOC reduct.:VOC incr.)
Marginal	100 TPY	1.1 : 1
Moderate	100 TPY ^a	1.15 : 1
Serious	50 TPY ^a	1.2 : 1
Severe	25 TPY ^a	1.3 : 1
Extreme	10 TPY ^a	1.5 : 1

^a States have the option of electing to define major source at 5 tons per year (and accepting other conditions) as opposed to demonstrating further reasonable progress. See text.

It should be noted that some states may elect to opt out of the reasonable further progress (RFP) demonstration required by the CAA, which requires states with some classifications of nonattainment areas to demonstrate a 15 percent reduction in VOC emissions within the first six years of enactment (i.e., by November 1996). States electing to opt out of the RFP demonstration must define major source at the five ton per year level and accept other conditions.

The CAA also requires that major sources in nonattainment areas offset any new VOC emissions with reductions in VOC emissions from within their facility or from other facilities located within the nonattainment area. This offset requirement results in a net decrease in VOC emissions for sources affected by the NSR program. As shown in Exhibit 7-B-1, the required offsets are a function of the classification of the nonattainment area and increase with increasing ozone nonattainment status.

Sources affected by the NSR program are also required to reduce emissions to LAER. LAER determinations are typically based on the minimum expected performance of air pollution control devices.

The reductions achievable by control devices are well established and as shown in Exhibit 7-B-2 exceed 95 percent.

EXHIBIT 7-B-2
EFFECTIVENESS OF COMMON VOC CONTROL DEVICES

Control Device	Minimum Expected Reduction Efficiency (Percent)
Thermal Oxidizer	98%
Carbon Absorber	95%
Condenser	95%

Because facilities switching to VOCs would be required to install LAER, and controls are capable of reducing emissions by 95 percent, EPA would expect the projected increases in VOC from NSR affected facilities to be reduced by at least 95 percent. These facilities must offset any residual emissions (i.e., the remaining five percent) by the amount specified in Exhibit 7-B-2, thus mitigating any impacts from switching from ozone depleting substances to VOCs.

ATTACHMENT 7-C
PROPORTIONALLY ADJUSTED PROPELLANT AND SOLVENT RELEASES FROM A
MODEL FACILITY

To estimate the releases at a single facility using ODSs as propellants and solvents. The following approach was used:

- The fraction of propellant and solvent use to the total use of ODSs in the aerosols sector were calculated. For example, approximately 37.8 and 5.1 million kg of solvent and propellant were respectively consumed in the aerosols sector totaling 42.9 million kg. Thus, 87 percent of the emissions came from solvent uses and 13 percent came from propellant uses.
- Each fraction was multiplied by the emissions estimates from the respective type of manufacturing facility. These estimates are provided in Exhibit 6-1. For example, 87 percent of 2,800 kg equals 2,450 kg and 13 percent of 144,140 kg equals 18,750 kg.
- The two estimates were added to obtain a single proportionally adjusted release from a facility based on the relative use of propellants and solvents in an aerosol filling station.

Proportionally Adjusted Releases From Model Plant Using Both Solvent and Propellant: 21,200 kg per Year
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